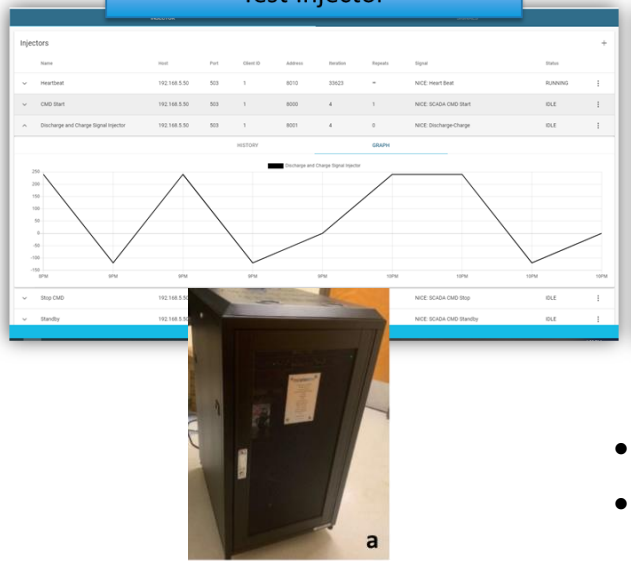
Demonstration and economy of Energy Storage Systems based on Second-Life Electric Vehicle Batteries

DOE Peer Review
October 2021

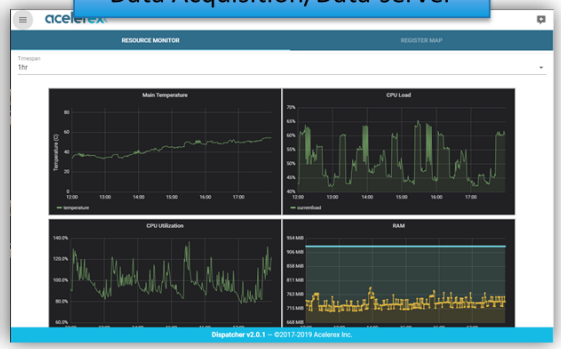
Paul P. Leufkens,
Reece Chimento,
Alyssa McQuilling

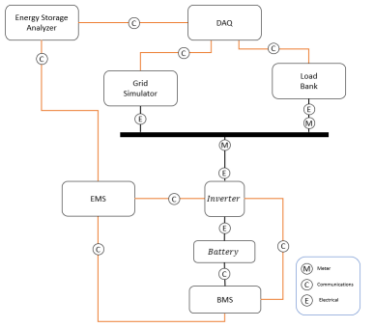
1. System Testing at Southern Research

Test Injector



Data Acquisition/Data server





- FOM test bed: 4 pads, total 1.1 MW
- BTM: 72 kW Grid Simulator & Load Bank with NICE Distributed Power Energy Storage System (DPESS)
- Remote control, monitoring and DAC
  - Energy Storage Analyzer (ESA)
  - Web-based Test Injector
  - Cloud-based Data Server

  Enabling big data, 1500 channels
- 12 kW DC Cycler, up to 3 channels

2. Findings variability in Second-use Packs

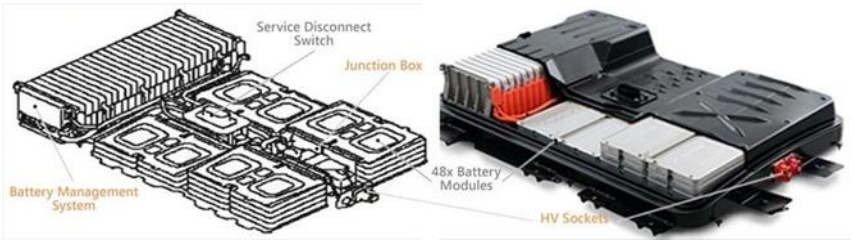
2011 Nissan Leaf batteries

- rated 24 kW rated originally
- second use, 16 kWh at 0.5C
  - after 6 years on the road and between 15,000 and 50,000 miles

In order to optimize a system of 6 packs the considerations is made:

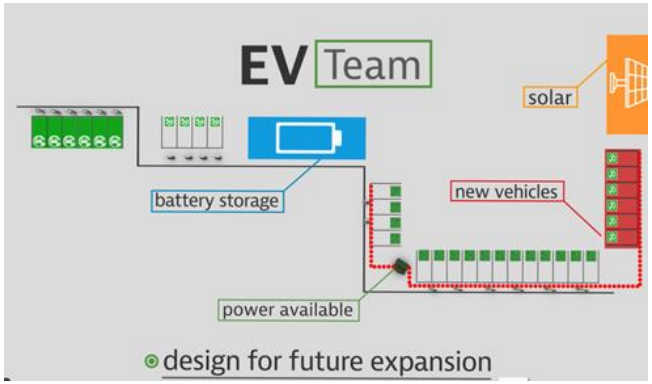
- Each battery pack and BMU does not behave exactly the same, system (battery array) performance must be considered

Expecting that degradation takes 3,000 to 5,000 full cycles a test program is designed for 3 months 24/7



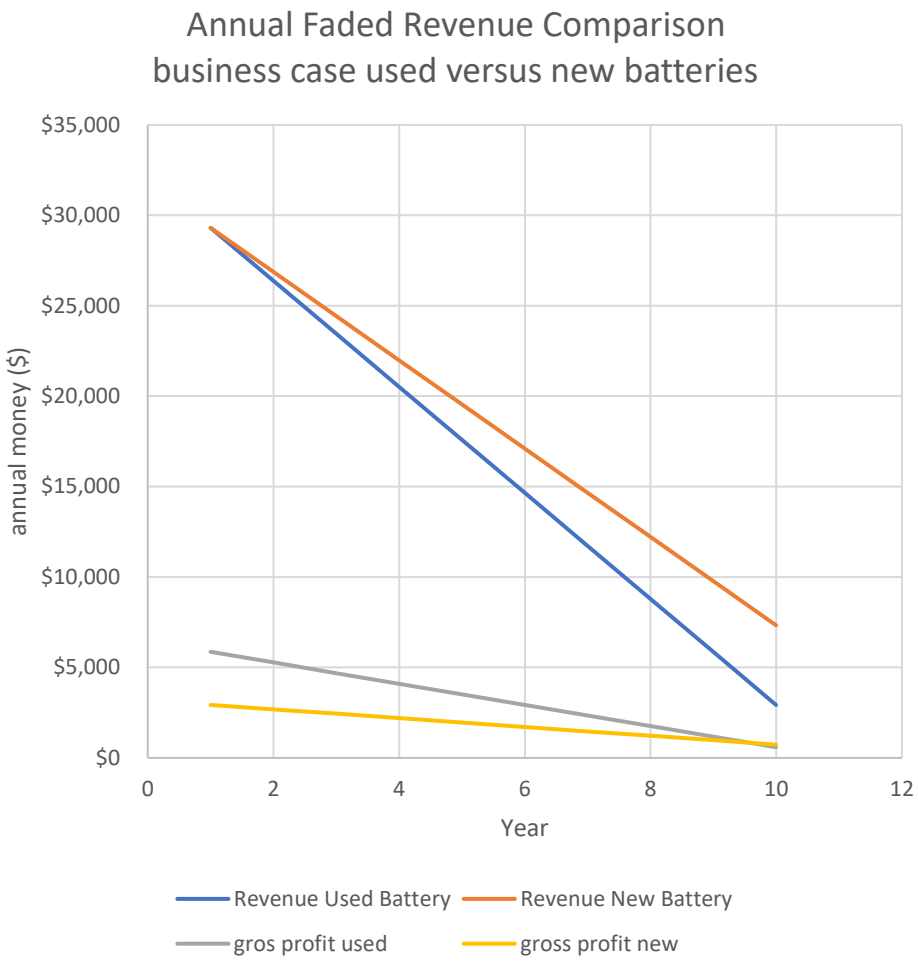
- Within each pack, voltage monitoring indicates that cells age and perform differently over time:
  red is lower V and green higher V
- If packs would be opened for re-processing prior to second use, cells can be measured and restacked into arrays and BMS adapted to optimize the system behavior
- We investigate potential savings of utilizing whole packs as such, especially if the second use packs come from an array that is close after test selection

3. Remote testing Pilot in Atlanta for the PSC Georgia: Second-use EV BESS added to EV charging station



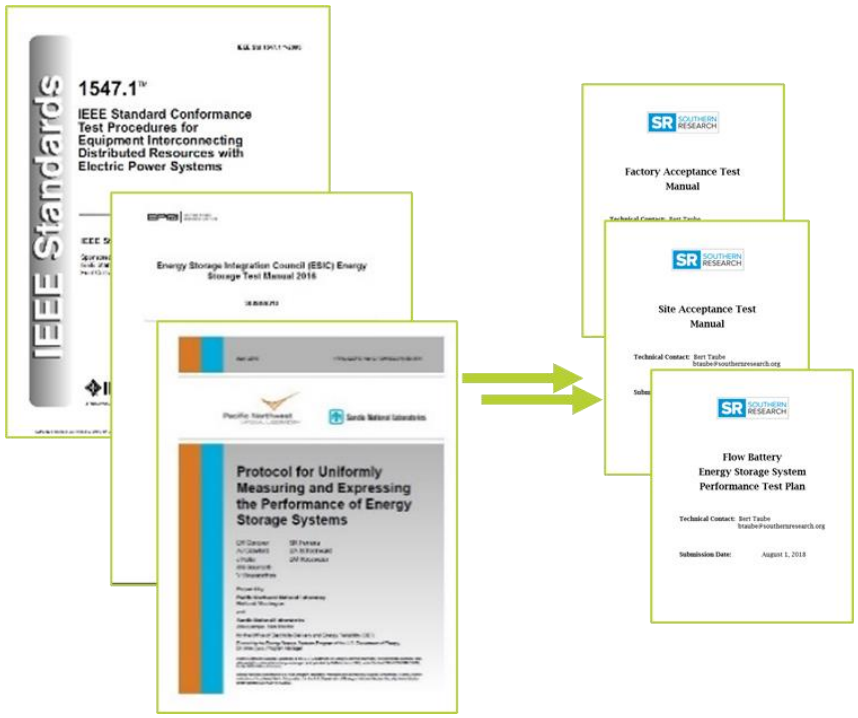
- Customer: Georgia Public Services Commission with Georgia Power
- Grid-connected Second-use EV BESS for mobility hub with level-2 and fast EV charging
  - 62 kW fast charging, even 2 in parallel
- Public benefits of project:
  - Support further development of the energy storage sector
  - Keep EV charging affordable
  - Provide alternative for excess 2nd use batteries (esp. NISSAN-Leaf)
  - Insulate the grid from (demand) spikes
- SR will commission the BESS, monitor performance, and test use cases for half a year

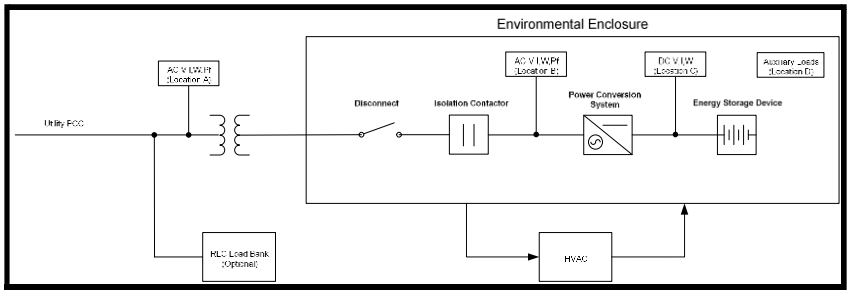
4. Economic: business case used versus new



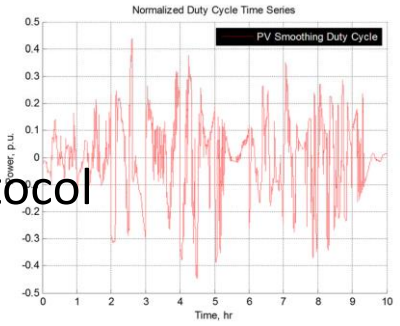
- Minimum demand charge required for ES projects to be economic is $9/kW to $15/kW
- BTM business modes of storage systems are more scalable when multiple savings or stacked services are pursued.
- The upfront capital cost is critical to minimize for BTM storage systems to be economic when the storage system provides 1 or 2 stacked services
- A 2h system provides more profit than 1h.

A. The ESRC develops ESS Test Manuals based on specific needs and the most relevant Standards

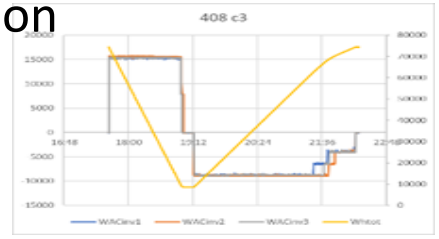




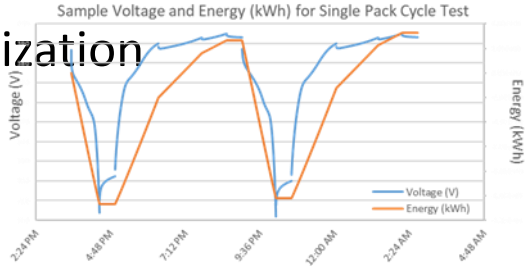
- IEEE 1547 tests more technically PCS than performance batteries
- Typical program:
  - Duty cycles
  ~ Sandia/PNNL protocol



  - AC characterization
  ~ ESIC manual



  - DC characterization



The Energy Storage Research Center at Southern Research was established with support from the U.S. Department of Energy, Oak Ridge National Laboratory and the State of Alabama.

U.S. DEPARTMENT OF ENERGY

Office of ELECTRICITY